

Statement of

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before the

Committee on Science and Technology
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*NASA's Science Programs:
Fiscal Year 2009 Budget Request and Issues*

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Mr. Chairman, Ranking Minority Member, and members of the Committee: thank you for inviting me here to testify today. My name is Berrien Moore III. For the past 20 years, I was Director of the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire. Recently, I have assumed the position of Executive Director for a new nonprofit organization, Climate Central, to be located in Princeton NJ and Palo Alto, CA. I appear, today, largely in my capacity as the recent co-chair of the National Research Council (NRC)'s Committee on Earth Science and Applications from Space, which authored the first "decadal survey" for the Earth Sciences and as the current chair of the National Research Council (NRC)'s Committee on Earth Studies of the Space Studies Board. This said, the views expressed in today's testimony are my own, but I believe they reflect community concerns.

Mr. Chairman, the world faces significant and profound environmental challenges: shortages of clean and accessible freshwater, degradation of terrestrial and aquatic ecosystems, increases in soil erosion, changes in the chemistry of the atmosphere, declines in fisheries, and above all the rapid pace of substantial changes in climate. These changes are not isolated; they interact with each other and with natural variability in complex ways that cascade through the environment across local, regional, and global scales. Information from NASA and NOAA environmental satellites is critical in addressing these problems, but as a result of significant cuts over several past budget cycles, growth in the cost of accessing space and in development of instruments, and inflation, we find ourselves with a growing mismatch between needs and resources. The fiscal year 2009 budget for NASA begins to redress some of this imbalance, but much more will be needed for many budget cycles to come.

I will now turn to the specific questions included in the letter of 28 February 2008 that I received from the Committee:

- 1. Do you believe NASA's space science program, and especially the Earth science program, is moving in the right direction? What, if any, changes would improve the program, and why? Please elaborate on your perspectives.**

Last June, this subcommittee held a hearing, "NASA's Earth Science and Applications Programs: Fiscal Year 2008 Budget Request and Issues." In opening statements, the chair of the subcommittee (Udall) and its now ranking minority member (Feeney) stated that:

"I called today's hearing for the purpose of examining how well NASA's plans and programs compare to the priorities of the decadal survey, and the extent to which NASA intends to support those priorities in the FY 08 budget and beyond. As numerous witnesses before this Committee have testified, the situation facing NASA's Earth Science program is not good...to quote the Decadal Survey, the nation's system of environmental satellites is 'at risk of collapse'

Rep. Mark Udall (D-CO)

“NASA's Earth Sciences program has produced stunning scientific results, often demonstrating, for the first time, measurements and capabilities that have never before been accomplished. I want that record of achievement to continue, and it's also my desire that we build upon the program's success to enable the goals established in the Decadal Survey.”

Rep. Tom Feeney (R-FL)

The subcommittee hearing focused on NASA Earth science programs in general and the recommendations of the recently completed National Research Council decadal survey, “Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond” in particular. The decadal survey outlined near-term actions meant to stem the tide of capability deterioration and continue critical data records, as well as forward-looking recommendations to establish a balanced Earth observation program designed to directly address the most urgent societal challenges facing our nation and the world.

Testifying on behalf of the Decadal Survey steering committee, in which I served as co-chair, Dr. Richard Anthes, President of the University Corporation for Atmospheric Research, outlined the key elements of the recommended program:

- Restoration of certain measurement capabilities to the NPP, NPOESS, and GOES-R spacecraft in order to ensure continuity of critical data sets.
- Completion of the existing planned program that was used as a baseline assumption for this survey. This includes (but is not limited to) launch of GPM in or before 2012 and securing a replacement to Landsat 7 data before 2012.
- A prioritized set of 17 missions to be carried out by NOAA and NASA over the next decade. This set of missions provides a sound foundation for Earth science and its associated societal benefits well beyond 2020.
- A technology development program at NASA with funding comparable to and in addition to its basic technology program to make sure the necessary technologies are ready when needed to support mission starts over the coming decade.
- A new “Venture” class of low-cost research and application missions that can establish entirely new research avenues or demonstrate key application-oriented measurements, helping with the development of innovative ideas and technologies. Priority would be given to cost-effective, innovative missions rather than ones with excessive scientific and technological requirements.
- A robust NASA Research and Analysis program, which is necessary to maximize scientific return on NASA investments in Earth science. Because the R&A programs are carried out largely through the Nation’s research universities, such programs are also of great importance in supporting and training the next generation of Earth science researchers.
- Suborbital and land-based measurements and socio-demographic studies in order to supplement and complement satellite data.
- A comprehensive information system to meet the challenge of production, distribution, and stewardship of observational data and climate records. To

ensure the recommended observations will benefit society, the mission program must be accompanied by efforts to translate raw observational data into useful information through modeling, data assimilation, and research and analysis.

In order to lay the foundation for implementing the full set of recommendations during the next decade, we further recommended these very near-term actions:

First, NASA should commit to and begin to implement its recommended Decadal Missions. Although, the NASA budget for Earth Sciences is not now adequate to implement the survey recommendations (see next question), a useful start can be made with modest resources. The survey's initial seven missions (2010-2013) should begin in 2008; the first four (CLARREO, SMAP, ICESat-II, and DESDynI) should begin intensive Phase A activities and the next three (for the time period 2013-2016 -- HypIRI, ASCENDS, and SWOT) should begin pre-Phase A studies. Increment needed beyond President's Request in FY08: \$90 million.

Second, NASA should increase its suborbital capabilities. NASA's airborne programs have suffered substantial diminution and should be restored. In addition, NASA should lead in exploiting unmanned aerial vehicles (UAV/technology). Both conventional and UAV aircraft are needed for instrument development, and hence risk reduction and technology advancement, and for their direct contribution to Earth observations. Increment needed beyond President's Request in FY08: \$10 million.

Third, NASA should increase support of its Research and Analysis (R&A) program and in Earth System modeling. Improved information about potential future changes in climate, weather, and other environmental conditions is essential for the benefit and protection of society. This improvement will come from: a) better observations (the recommended missions and enhanced suborbital capabilities); b) more capable models of the Earth System; and c) a vigorous research program to use the observations in models and interpret the results. The R&A program has suffered significant cuts in recent years and these should be reversed. R&A investments are among the most cost-effective as they directly exploit on-going missions, advance knowledge to better define what is needed in the future, and sustain and develop the requisite scientific and engineering workforce. Increment needed beyond President's Request in FY08: \$20 million.

The President's fiscal year 2009 budget for NASA includes a major new initiative in Earth science and applications, including a plan to provide \$910 million over five years (FY2009-2013) that addresses to varying degrees the items above and begins implementation of the decadal survey's nearest-term recommendations. In addition, the budget provides funding to restore the OMPS-L sensor to the NPOESS Preparatory Project (NPP) spacecraft, which is now scheduled for launch in 2010, integrate a spare CERES instrument on NPP, and support instrument development and analyses to identify

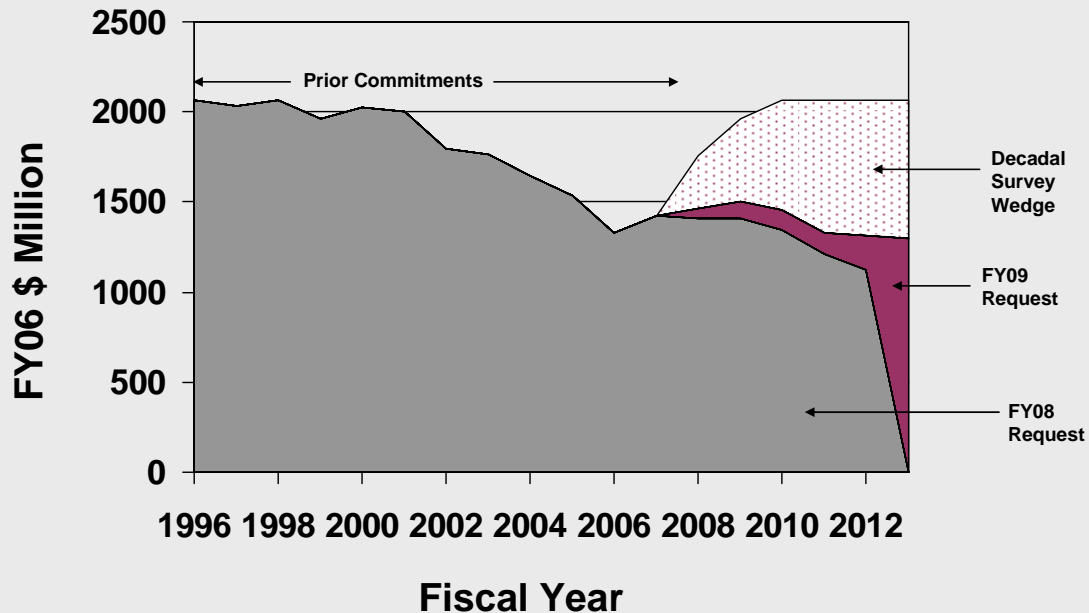
a suitable satellite platform for hosting the total solar irradiance sensor (TSIS). All of this is very welcome news, but I have several concerns:

- **The Initiative's funding comes at the expense of other NASA science programs:** Approximately two-thirds of the additional \$910 million over five years are obtained by drawing from each of the three other science areas in the science mission directorate (SMD). In the planetary portfolio, some \$200 million came from the Mars program as a result of delay in a Scout mission procurement. The contribution from the Heliophysics division included changes such as a stretching out in the development of the Solar Probe mission. The Astrophysics division contributions were largely obtained by reducing funding in the out-years of the five-year plan, (2011-2013).

Earth science requires an ongoing commitment of funding at a higher level than is provided in the FY09 budget run-out and redistribution of resources simply is not a long-term solution to the problem. As noted by members of this committee, NASA has been asked to accomplish too much with too little; what is needed is an increase in the overall top-line budget for NASA, which in turn will allow an increase in NASA's science budget. Absent such an increase, it will not be possible to restore Earth science funding to the needed FY2000 levels (as recommended in the decadal survey) without inflicting great damage to the other science portfolio areas.

- **As illustrated below, the Initiative still falls very short of what is required to implement the Decadal Survey.** Below is an updated version of a graphic that we prepared for the Decadal Survey; it now includes budget profiles from the FY08 and FY09 Presidential budgets (FY08 and FY09). As before, we present the data in FY06 dollars to remove the effects of inflation. It is evident that after an initial rise, funding for Earth science at NASA actually begins to decrease again.
- **The climate record from NPOESS is still very much in danger.** As this committee knows too well, cost and schedule problems triggered a Nunn-McCurdy review of the NPOESS program. Many of the specific capabilities related to better understand, predict, and eventually mitigate the effects of global climate change were lost in the restructured program. The changes to NPP and the decision to find a platform for a new TSIS are welcome news, but, as detailed in a forthcoming NRC report, far from what is needed. Finally, NOAA must have adequate resources to support the development and stewardship of Climate Data Records. This was addressed in both the Interim and Final reports of the decadal survey, and I call it again to the attention of the Committee.

Comparison between President's **FY09** NASA request and NRC recommendation



Cross-disciplinary programs re-categorized in FY09. ES budget added back into FY09 request for consistency

In summary, I am encouraged by the renewed emphasis on Earth science at NASA; however, without additional resources, there is a limit to what management's best intentions can accomplish. The NASA Earth science program is doing what it can with the resources it has been given; it simply has not been given enough to accomplish all that is expected of it, and, more importantly, all that the Nation needs. I address explicitly what further needs to be done in my answer to Question Two below.

2. What, if any, challenges do you foresee for the future of the NASA Earth science program as presented in the FY 2009 budget request? What are your suggestions for addressing those challenges?

As I noted in my response to question #1, the FY09 NASA Earth science program request is very good news, but I am concerned about whether the initiative can be sustained and whether it is advisable to fund Earth science at the expense of other NASA science programs. The planned addition of \$910 million over five years to the Earth science budget also still leaves a very large shortfall in what is needed to execute the recommendations of the decadal survey (see again the figure above).

The 17 missions recommended by the decadal survey are organized into sets in order to take most advantage of concurrent observations to advance our understanding of Earth as

a system—four missions are recommended for launch in the 2010-2013 timeframe. In contrast, the FY09 budget plans for one to launch in 2012 and a second in 2015. A third is slated for 2017. This makes the concurrent observations between missions very difficult. The overall program recommended by the decadal survey is simply not being adequately implemented.

I would like to suggest two challenging and important actions: First, both the Science Mission Directorate and the Earth Sciences Division need a budget plus above the President's request. Congress did this last year, and the result was particularly positive since it served to not only achieve the direct benefits one might expect, but it also encouraged industry to begin to invest anew in technologies relevant to the missions recommended by the decadal survey. For the Earth sciences, the target for this Congressional increase should be a) more rapid implementation of the first four missions and b) a greater technology investment in the missions in the 2013-2016 timeframe—particularly the first two or three missions in the 2013-2016 timeframe. Second, Congress should address the inadequacies in the out-year budget; this could be particularly important as the executive branch of government goes through a transition.

3. As NASA begins to plan missions recommended in the National Academies Earth science Decadal Survey, what actions do the Decadal Survey and other community input recommend to further the applied use of the data for societal benefits and the transition of research data into operational service? What, if any impediments exist that could constrain progress in this area, and how can they be overcome?

In the decadal survey report, the steering committee expressed a particular concern with the lack of clear agency responsibility for sustained research programs and the transitioning of proof-of-concept measurements into sustained measurement systems. To address societal and research needs, both the quality and the continuity of the measurement record must be assured through the transition of short-term, exploratory capabilities, into sustained observing systems. The elimination of the requirements for climate research-related measurements on NPOESS is only the most recent example of the nation's failure to sustain critical measurements. Therefore, our committee recommended that, *"The Office of Science and Technology Policy (OSTP), in collaboration with the relevant agencies, and in consultation with the scientific community, develop and implement a plan for achieving and sustaining global Earth observations."* In addition, we recommended that the plan recognize the complexity of differing agency roles, responsibilities, and capabilities as well as the lessons from implementation of the Landsat, EOS, and NPOESS programs.

I am pleased to note that this recommendation is being taken very seriously by the OSTP. It is my understanding that they are developing an overall strategy for Earth observations policy, which will include interagency issues of the kind raised in the decadal survey as well as issues related to the U.S. contribution to a global observing system and GEO.

The issue of an overall national strategy and plan for Earth observation is of central importance, and I return to it below in my answer to the Committee's final question.

Another area that requires attention is the NASA applied sciences program. Last year, the NRC completed a review of this program; at the end of my testimony, I attach a copy the recommendations from that report. These recommendations are entirely consistent with those in the decadal survey; we also noted that the key to meeting societal needs for Earth observation data is to have the potential "users" of these data represented in a substantive way from the earliest stages of mission development, determining priorities, designing products, and evaluating benefits. As noted in my response to question #1, renewed support for the NASA Research and Analysis program is also critical to the success of the applied sciences program.

4. The Committee on Science and Technology plans to reauthorize NASA this year and in so doing will communicate policy direction to NASA as well as to the next Presidential Administration. What, in your view, are the most important issues with respect to NASA's Earth science programs that Congress should consider in its reauthorization of NASA?

NASA should consider how to best leverage its Earth science program resources to accomplish both the intended science and societal outcomes as described in the decadal survey. An integrated programmatic approach is required to align efforts towards these common goals. This means coordination of, for example, NASA's technology development investments to ensure needed technologies are ready to support recommended missions. It also will require additional support to applications end users' involvement in mission formulation, and targeted R&A investments to begin work on laying the scientific foundation needed to maximize the value of mission observations. In other words, we need to eliminate the traditional "stove pipe" approach, which often decouples funding priorities between program elements; sustained programmatic attention is required to implement the needed missions in a reasonable timeframe. Yet, as we stressed in the decadal survey, the program must also provide opportunities for entirely new measurements and approaches and so programmatic flexibility must be retained to both accommodate and enable new discoveries.

A key to making more efficient use of scarce budget resources is to develop a comprehensive approach to Earth observations from space. As stated above in my response to question 3, the decadal survey committee expressed great concern that the nation's civil space institutions (including NASA, NOAA, and USGS) are not adequately prepared to meet society's rapidly evolving Earth information needs. These institutions have responsibilities that are in many cases mismatched with their authorities and resources: institutional mandates are inconsistent with agency charters, budgets are not well matched to emerging needs, and shared responsibilities are supported inconsistently by mechanisms for cooperation. Further, these are issues whose solutions will require

action at high levels of the federal government. It was for these reasons that we recommended development and implementation of a comprehensive plan for achieving and sustaining global Earth observations.

Returning to my opening comments, we know that the planet's environment is changing on all spatial scales including global, and change is rapid, perhaps more rapid than at any time in human history. Further, we know that many of these changes are occurring as a result of human activities. These human-induced changes are over and above the stresses imposed by the natural variability of a dynamic planet and are intersecting with the effects of past and existing patterns of conflict, poverty, disease, and malnutrition.

As I noted, the changes cascade through the Earth's environment in ways that are difficult to understand and often impossible to predict. Therefore, at the least, these human-driven changes in the global environment will require that societies develop a multitude of creative responses, including strategies for mitigation and adaptation. Earth observations are a critical part of developing these responses.

The linked challenges of confronting and coping with global environmental changes, and addressing and securing a sustainable future, are daunting and immediate, but they are not insurmountable. These challenges can be met, but only with a new and even more vigorous approach to observe and understanding our changing planet and with a concomitant commitment by all to alter our actions.

Box S.1 Recommendations

RECOMMENDATION 1: ASP should be assigned the responsibility within NASA to review and help establish the requirements and guidelines offered in Chapter 5 of the Decadal Study (NRC, 2007a) for effective extension of data and research to applications that meet societal needs. As part of this action, the committee recommends incorporating an ASP representative on NASA mission design and selection teams to aid ASP in increasing the use and impact of NASA products in the user community.

RECOMMENDATION 2: ASP, in collaboration with other parts of NASA, should help to develop a formal plan and structure for effective transitions from research to operations with direct input from the entire range of users and with support from Congress.

RECOMMENDATION 3: ASP should link NASA data and research to users and beneficiaries through communication in both directions, not simply in one direction that disseminates NASA products without user feedback. Communication between ASP and external users should be enhanced, as should ASP's communications with other groups in NASA that conduct research on Earth-based observations.

RECOMMENDATION 4: ASP should develop processes for sustained interactions with a broader base of users and beneficiaries of NASA observations. ASP should assess user benefits of applications of NASA observations, with public comment and user reviews, in order to evaluate levels of importance to society and to inform the development of outcome metrics. ASP should prioritize intended societal benefits from NASA products and focus efforts on high-priority benefits.

RECOMMENDATION 5: To enhance the program's success in facilitating effective partnerships between NASA and users of NASA products to generate societal benefits, ASP should

1. directly engage with a broader community of users—not just federal agencies;
2. add rigor with respect to performance metrics;
3. evaluate the number and focus of its applications areas;
4. improve the transparency and documentation of the process by which a partner agency engages the broader community, including clarification of the partner agency responsibilities in realizing the shared goal of benefits to society; and
5. clarify and broaden its policies regarding productive relationships and collaborations with the private sector, including but not limited to remote sensing data products.